



**US Army Corps  
of Engineers**  
Waterways Experiment  
Station

---

# **Preliminary Data Summary October 1999 Field Research Facility**

by Clifford Baron, Michael Leffler, Kent Hathaway,  
Brian Scarborough, Ray Townsend, William Grogg,  
Dan Freer

Coastal and Hydraulics Laboratory

The logo for Waterways Experiment Station (WES), consisting of the letters "WES" in a bold, italicized font, with each letter composed of horizontal lines.

Approved for Public Release; Distribution is Unlimited

Prepared for Headquarters, U.S. Army Corps of Engineers

# **Contents**

---

1	Introduction .....	1
2	Meteorological Data .....	5
3	Wave Data .....	10
4	Current Data .....	15
5	Visual Observations .....	18
6	Water Levels .....	20
7	Bathymetry .....	22

## **List of Figures**

---

<u>No.</u>		
1	FRF Location Map .....	1
2	Month at a Glance .....	2
3	Instrument Locations at FRF .....	4
4	Meteorological Monthly Summary .....	6
5	Wave Heights and Periods .....	14
6	Water Levels .....	20
7	CRAB Profiles .....	22
8	CRAB Profile Envelope .....	23
9	FRF Bathymetry (27 October 99) .....	24

## **List of Tables**

---

<u>No.</u>		
1	Instrument Status/Data Availability .....	3
2	Gauge Locations .....	4
3	Meteorological Data .....	7
4	Wave Data .....	11
5	Current Meter Data .....	16
6	Visually Observed Current Data .....	17
7	Visual Observations .....	19
8	Water Levels .....	21

# 1 Introduction

---

The U.S. Army Corps of Engineers Waterways Experiment Station, Coastal and Hydraulics Laboratory (CHL), Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. Central to the FRF is the research pier, a reinforced concrete structure which extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the NGVD (1929 National Geodetic Vertical Datum).

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This is a preliminary which provides basic data soon after collection. Since they are preliminary further quality control may be applied to the data and made available via the internet at <http://www.frf.usace.army.mil>. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919)261-6840 ext.222 (*baronc@wes.army.mil*).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8 documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 2.

Times given in the report are referenced to eastern standard time (EST).



Figure 1. FRF Location Map

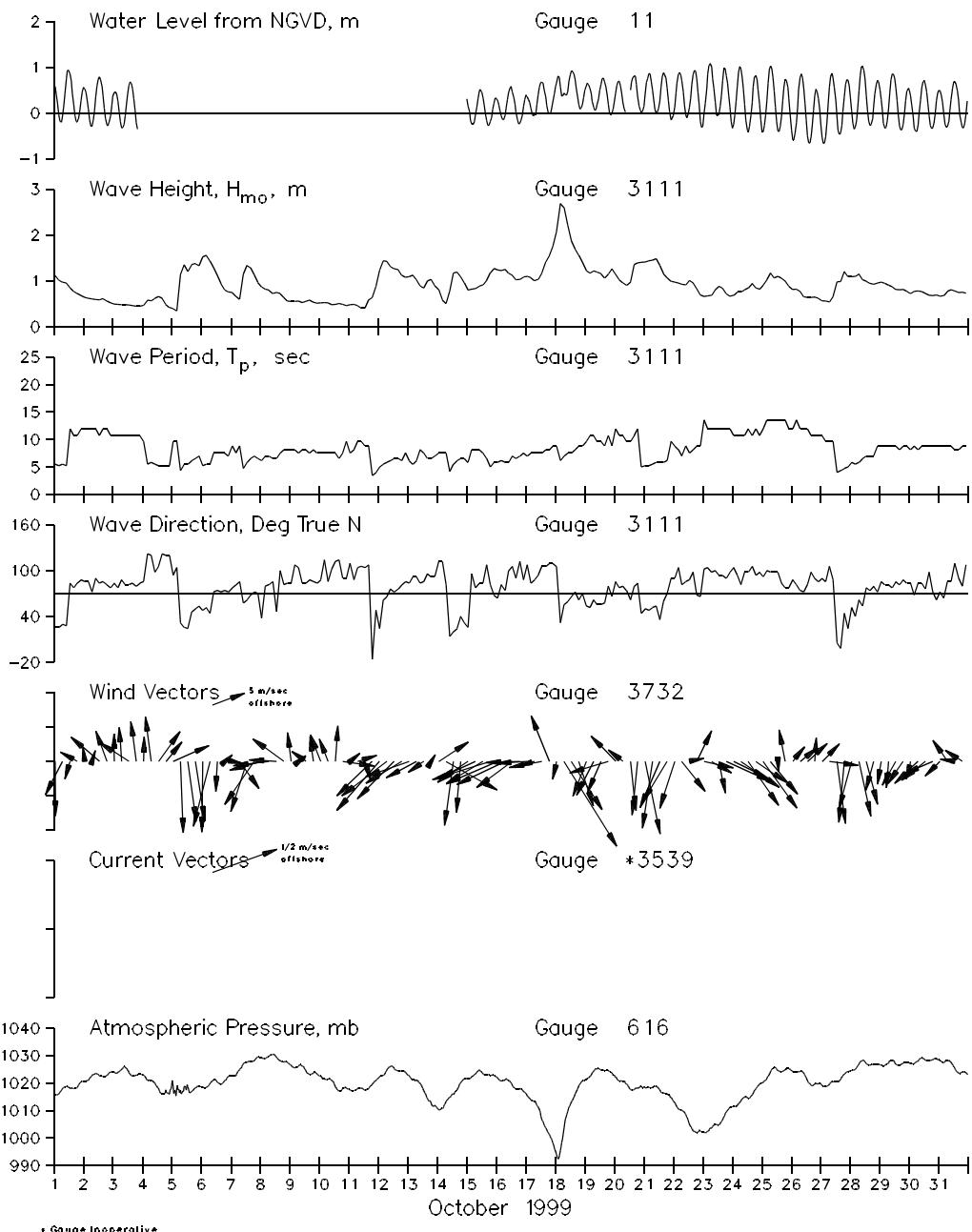


Figure 2. Month at a Glance

**Table 1**  
**Instrument Status/Data Availability**

**Table 2 Gauge Locations**

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates Crossshore m	Longshore m	Gauge Depth NGVD, m	Water Depth NGVD, m
616	Atmospheric Pressure	36 10' 57.03"	75 45' 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11' 1.23"	75 44' 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10' 57.71"	75 44' 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11' 1.04"	75 44' 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11' 19.14"	75 44' 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11' 11.28"	75 44' 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11' 13.70"	75 44' 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11' 12.48"	75 44' 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11' 14.06"	75 44' 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10' 5.10"	75 41' 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11' 23.57"	75 44' 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11' 1.25"	75 44' 42.60"	596.49	514.20	Surface	-7.62

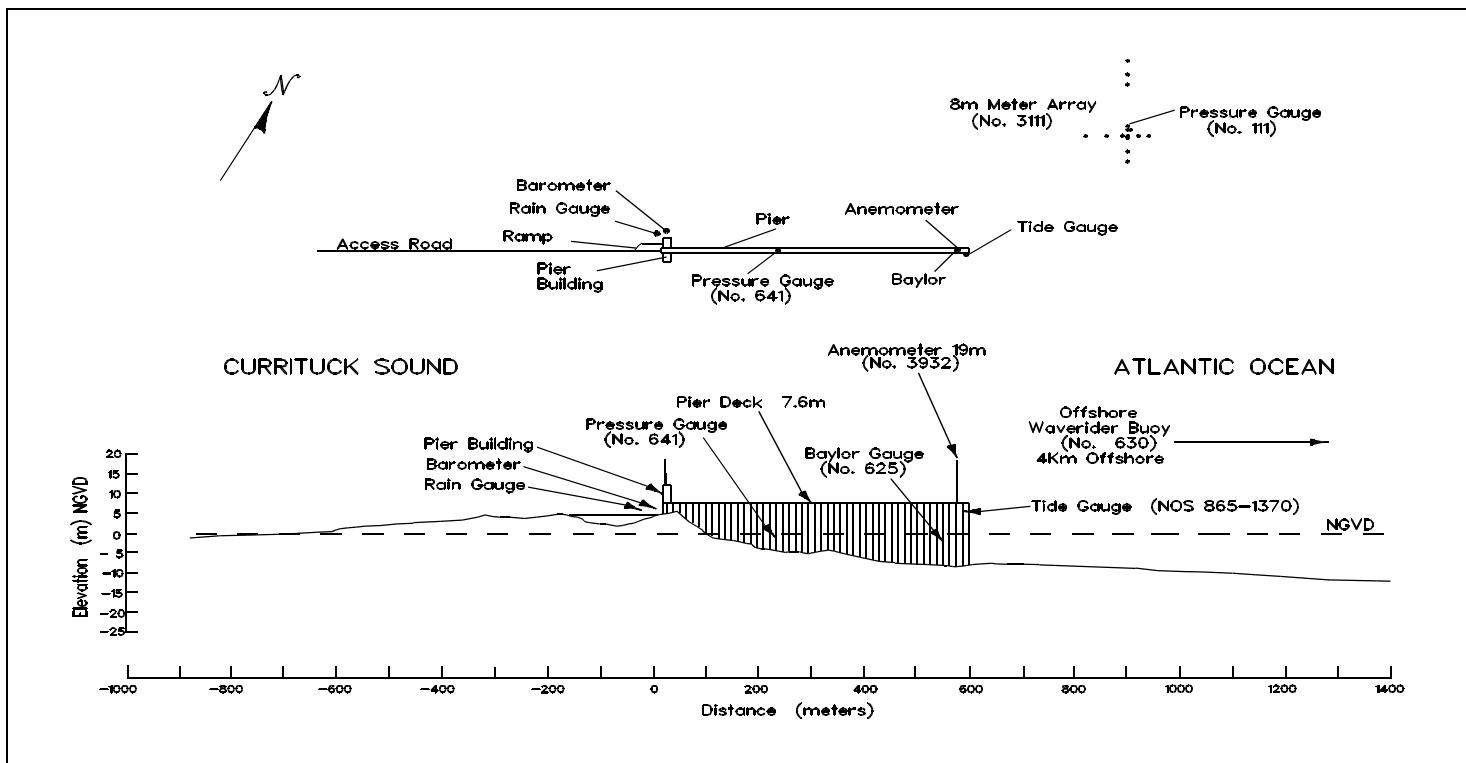


Figure 3. Instrument Locations, Elevations From NGVD

## 2 Meteorological Data

---

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $m/s \times 1.943 = kn$

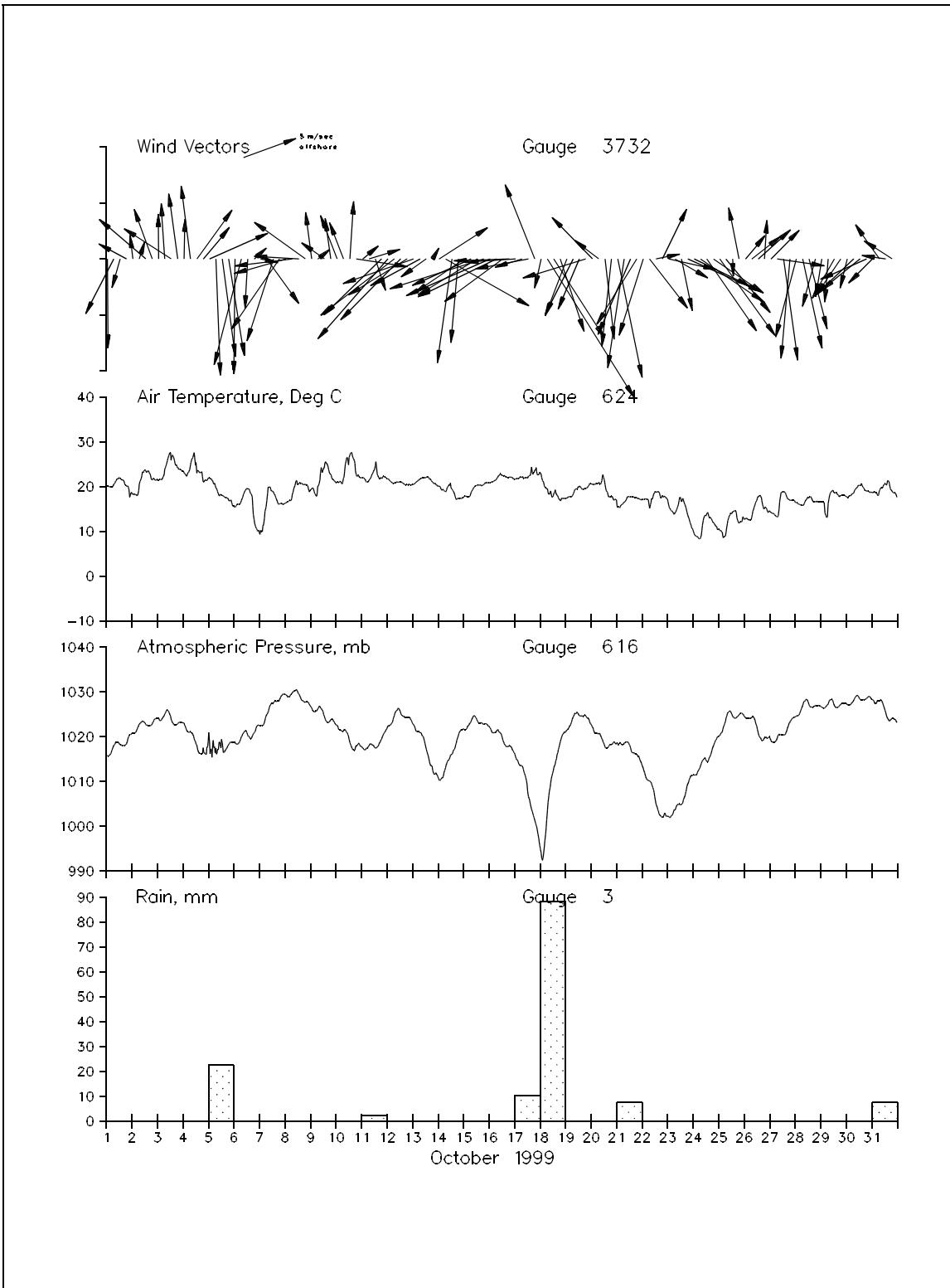


Figure 4. Meteorological Monthly Summary

**Table 3**  
**Meteorological Data**

Oct 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	1	225	16.8	1023.0	0
	700	6	27	20.5	1018.2	0
	1300	3	16	21.8	1018.3	0
	1900	3	118	20.2	1018.5	0
2	100	2	172	18.4	1020.9	0
	700	2	197	20.5	1022.9	0
	1300	5	130	23.6	1022.8	0
	1900	5	160	21.5	1023.0	0
3	100	4	179	21.5	1024.1	0
	700	5	176	23.9	1025.2	0
	1300	5	122	25.9	1024.0	0
	1900	6	172	24.3	1023.0	0
4	100	4	181	23.1	1023.1	0
	700	7	172	24.8	1021.2	0
	1300	5	215	23.0	1018.3	0
	1900	4	219	21.1	1017.6	0
5	100	6	246	22.0	1018.8	0
	700	10	357	19.8	1017.5	23
	1300	9	352	18.1	1018.7	0
	1900	9	350	17.0	1018.4	0
6	100	10	1	15.5	1018.8	0
	700	10	14	16.9	1020.0	0
	1300	4	3	19.5	1020.4	0
	1900	1	227	12.7	1021.0	0
7	100	2	282	10.2	1022.6	0
	700	5	324	16.9	1025.1	0
	1300	8	18	18.8	1027.5	0
	1900	8	34	16.1	1028.4	0
8	100	5	74	16.5	1029.5	0
	700	5	83	18.3	1030.0	0
	1300	4	93	20.6	1029.6	0
	1900	6	125	20.6	1027.8	0
9	100	4	172	19.6	1026.5	0
	700	1	231	20.1	1026.3	0
	1300	2	125	24.4	1024.6	0
	1900	4	172	22.8	1023.8	0
10	100	4	159	21.1	1022.6	0
	700	3	158	21.9	1021.5	0
	1300	5	183	27.1	1018.8	0
	1900	5	278	22.6	1018.2	0

**Table 3**  
**Meteorological Data (continued)**

Oct 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	2	230	22.0	1017.6	0
	700	3	253	21.4	1018.2	2
	1300	3	342	24.6	1017.5	0
	1900	7	45	21.8	1019.7	0
12	100	10	41	21.8	1022.5	0
	700	8	52	20.9	1024.9	0
	1300	8	44	21.1	1025.3	0
	1900	6	58	20.5	1024.5	0
13	100	7	70	20.6	1022.8	0
	700	5	61	21.7	1021.0	0
	1300	3	54	22.1	1017.3	0
	1900	1	210	21.0	1012.6	0
14	100	5	236	20.1	1010.5	0
	700	9	299	18.9	1013.2	0
	1300	9	7	19.5	1016.3	0
	1900	8	5	17.4	1020.3	0
15	100	5	55	17.9	1021.7	0
	700	6	65	18.7	1023.5	0
	1300	6	58	20.4	1023.6	0
	1900	9	72	20.5	1022.8	0
16	100	8	66	20.9	1022.0	0
	700	8	64	21.7	1021.3	0
	1300	6	53	22.5	1019.2	0
	1900	5	87	22.1	1018.2	0
17	100	4	86	21.8	1015.5	0
	700	3	73	22.2	1013.5	10
	1300	5	79	22.3	1006.7	0
	1900	7	158	23.8	1001.4	0
18	100	3	12	22.7	994.1	0
	700	15	328	19.5	1003.8	89
	1300	8	327	18.6	1013.2	0
	1900	7	342	16.8	1018.9	0
19	100	5	21	17.4	1021.4	0
	700	6	26	18.3	1024.5	0
	1300	5	23	20.1	1024.8	0
	1900	6	72	19.6	1024.8	0
20	100	5	135	20.7	1022.2	0
	700	3	127	20.8	1020.7	0
	1300	7	353	20.5	1017.8	0
	1900	8	6	17.9	1018.4	0

**Table 3**  
**Meteorological Data (concluded)**

Oct 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	11	348	15.3	1018.5	0
	700	10	8	16.6	1018.7	8
	1300	7	23	17.7	1017.6	0
	1900	7	31	17.5	1016.3	0
	22	100	7	17	1013.0	0
	700	6	322	15.1	1010.2	0
	1300	2	258	18.7	1005.1	0
	1900	5	205	18.1	1002.1	0
23	100	4	282	15.8	1002.3	0
	700	3	300	14.2	1003.7	0
	1300	5	348	16.6	1005.0	0
	1900	7	294	13.5	1009.6	0
	24	100	6	296	9.5	1011.6
	700	7	304	8.6	1013.6	0
	1300	8	325	14.1	1014.5	0
	1900	5	304	12.0	1018.1	0
25	100	8	324	10.3	1020.5	0
	700	6	320	9.8	1024.2	0
	1300	2	357	14.4	1024.7	0
	1900	5	168	11.8	1025.0	0
	26	100	3	220	12.9	1024.4
	700	3	231	13.2	1024.3	0
	1300	4	227	17.8	1021.0	0
	1900	3	183	15.1	1019.8	0
27	100	4	224	14.2	1019.3	0
	700	4	278	13.3	1019.7	0
	1300	9	352	18.9	1020.5	0
	1900	9	5	17.0	1023.3	0
	28	100	7	15	16.4	1024.7
	700	8	348	15.8	1027.0	0
	1300	6	345	17.6	1027.2	0
	1900	4	15	16.7	1027.1	0
29	100	3	9	16.6	1026.7	0
	700	4	4	16.2	1027.4	0
	1300	4	29	18.6	1027.0	0
	1900	4	34	18.0	1027.4	0
	30	100	3	14	17.7	1027.2
	700	5	46	18.7	1028.3	0
	1300	4	51	20.3	1028.4	0
	1900	4	66	19.0	1028.6	0
31	100	3	45	18.7	1028.3	0
	700	4	145	19.1	1028.1	7
	1300	2	98	20.7	1025.5	0
	1900	3	123	18.9	1024.2	0
			Resultant	Mean	Mean	Total
			2	23	18.8	1020.1
						139

## 3 Wave Data

---

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using an iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 Hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4**  
**Wave Data**

Oct 1999											
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider		
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec	
1	0100	0.45	7.6	0.67	8.6	1.12	5.6	26	1.35	5.9	
	0700	0.57	5.6	0.97	4.7	0.97	5.6	30	1.16	5.6	
	1300	0.51	5.3	0.88	11.2	0.86	12.0	84	1.01	5.3	
	1900	0.31	5.3	0.70	12.2	0.73	10.8	84	0.83	12.6	
	0100	0.31	11.7	0.59	10.3	0.64	12.0	86	0.75	12.6	
2	0700	0.22	12.2	0.60	11.7	0.61	12.0	72	0.61	11.8	
	1300	0.29	11.7	0.59	11.7	0.59	10.8	84	0.63	10.6	
	1900	0.26	3.0	0.61	11.7	0.56	12.0	82	0.63	11.8	
	0100	0.25	11.7	0.48	11.7	0.50	10.8	84	0.54	9.1	
3	0700	0.20	4.1	0.46	11.2	0.48	10.8	88	0.55	10.1	
	1300	0.26	10.7	0.44	11.2	0.47	10.8	82	0.52	10.6	
	1900	0.25	4.2	0.48	10.3	0.44	10.8	80	0.56	10.1	
	0100	0.28	5.9	0.44	10.3	0.47	9.8	86	0.58	9.1	
4	0700	0.41	5.2	0.59	5.5	0.57	5.9	120	0.70	5.6	
	1300	0.52	5.4	0.63	5.5	0.66	5.3	106	0.84	5.6	
	1900	0.37	5.3	0.53	5.5	0.49	5.3	120	0.74	5.1	
	0100	0.27	4.9	0.38	9.5	0.40	9.8	94	0.52	5.9	
5	0700	0.59	4.2	0.92	4.3	1.14	4.4	32	0.99	4.1	
	1300	0.77	5.5	1.10	5.6	1.21	5.6	24	1.35	5.6	
	1900	0.92	6.3	1.34	7.2	1.38	6.6	50	1.64	6.7	
	0100	0.88	5.2	1.42	5.4	1.52	5.3	48	1.78	5.9	
6	0700	0.94	5.5	1.38	6.0	1.44	5.6	44	1.58	5.1	
	1300	0.63	5.3	1.13	7.8	1.12	7.6	74	1.45	7.7	
	1900	0.48	7.6	0.83	7.6	0.80	7.6	74	1.08	7.7	
	0100	0.33	6.0	0.78	8.9	0.75	8.9	78	0.87	6.7	
7	0700	0.30	5.3	0.62	8.6	0.60	8.9	86	0.78	8.4	
	1300	0.77	5.5	1.32	5.5	1.34	5.9	62	1.35	5.0	
	1900	0.72	6.5	1.21	7.6	1.13	7.1	72	1.30	6.7	
	0100	0.47	5.4	0.92	6.5	0.87	6.2	38	1.00	6.3	
8	0700	0.45	5.4	0.83	6.6	0.80	7.1	82	0.94	7.7	
	1300	0.37	4.4	0.78	7.0	0.75	6.6	46	0.88	6.3	
	1900	0.41	8.3	0.70	7.2	0.64	8.2	82	0.80	7.7	
	0100	0.25	4.7	0.58	8.6	0.55	8.2	84	0.61	7.7	
9	0700	0.36	7.0	0.54	7.6	0.56	7.6	104	0.60	8.4	
	1300	0.26	4.6	0.52	7.6	0.56	8.2	84	0.60	8.4	
	1900	0.38	5.3	0.53	7.6	0.53	8.2	86	0.60	8.4	
	0100	0.23	5.7	0.47	7.2	0.52	7.6	88	0.60	8.4	
10	0700	0.37	6.5	0.50	8.1	0.52	7.6	86	0.62	6.7	
	1300	0.22	5.9	0.46	8.3	0.49	7.6	112	0.57	7.7	
	1900	0.34	7.0	0.48	7.8	0.49	7.6	90	0.58	8.4	

**Table 4**  
**Wave Data (continued)**

Oct 1999										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
11	0100	0.23	4.2	0.45	8.3	0.48	7.6	110	0.59	8.4
	0700	0.35	6.8	0.44	7.4	0.46	9.8	104	0.53	9.1
	1300	0.21	5.2	0.39	9.2	0.41	8.9	104	0.45	9.1
	1900	0.43	3.6	0.68	3.9	0.64	3.5	344	0.84	8.4
12	0100	0.67	4.8	1.16	4.8	1.23	5.0	24	1.18	4.8
	0700	0.89	5.7	1.44	6.0	1.43	5.9	66	1.71	5.9
	1300	0.75	4.9	1.23	6.6	1.27	6.6	72	1.44	6.7
	1900	0.71	6.1	1.11	6.1	1.12	6.2	82	1.24	6.3
13	0100	0.65	6.1	1.11	7.8	1.09	6.2	84	1.26	5.9
	0700	0.71	5.1	1.04	5.7	1.03	6.2	92	1.25	5.6
	1300	0.55	5.4	0.87	6.6	0.85	7.6	86	0.95	7.7
	1900	0.75	6.5	1.04	7.0	1.03	6.6	92	1.23	6.3
14	0100	0.53	7.8	0.77	7.4	0.81	7.6	112	0.95	7.2
	0700	0.24	6.8	0.43	7.4	0.50	7.6	82	0.65	7.7
	1300	0.72	5.4	1.08	4.9	1.17	5.6	20	1.23	5.3
	1900	0.63	5.6	1.02	6.1	1.09	6.6	40	1.25	5.6
15	0100	0.49	5.4	0.84	5.7	0.80	5.9	26	1.00	5.6
	0700	0.51	6.0	0.88	7.8	0.83	8.2	78	1.03	8.4
	1300	0.56	7.2	0.92	7.6	0.91	7.6	84	1.01	7.2
	1900	0.65	5.1	1.26	4.8	1.18	5.0	82	1.36	4.8
16	0100	0.65	5.1	1.27	5.9	1.24	5.9	64	1.47	6.3
	0700	0.72	5.3	1.26	6.0	1.25	5.9	74	1.37	5.9
	1300	0.81	6.1	1.10	6.8	1.12	7.1	106	1.33	5.9
	1900	0.60	5.6	1.06	7.0	1.03	7.1	112	1.12	6.7
17	0100	0.81	7.0	1.11	7.4	1.10	7.1	108	1.22	7.7
	0700	0.64	7.2	1.10	7.2	1.01	7.6	88	1.16	7.2
	1300	0.83	7.0	1.10	8.3	1.18	7.6	106	1.31	6.7
	1900	1.05	8.1	1.42	8.9	1.56	8.2	110	1.88	8.4
18	0100	1.49	9.2	1.79	9.2	2.07	8.9	106	2.15	9.1
	0700	1.25	7.2	inoperative		2.60	7.1	56	3.11	6.3
	1300	1.27	7.6	1.76	8.5	1.87	7.6	66	2.23	7.7
	1900	0.94	7.0	1.59	8.3	1.57	8.9	62	1.90	8.4
19	0100	0.76	8.3	1.24	10.7	1.23	9.8	54	1.64	10.6
	0700	0.62	11.2	1.29	10.7	1.22	10.8	62	1.32	10.1
	1300	0.62	9.5	1.27	9.9	1.16	9.8	56	1.33	9.1
	1900	0.61	9.2	1.08	8.9	1.15	10.8	80	1.15	10.6
20	0100	0.63	5.4	1.24	10.7	1.15	12.0	86	1.41	11.2
	0700	0.42	11.7	0.95	11.2	0.96	10.8	80	1.06	11.2
	1300	0.42	9.2	0.89	9.5	0.98	9.8	62	0.98	10.6
	1900	0.82	5.2	1.31	5.2	1.39	12.0	84	1.51	5.3

**Table 4**  
**Wave Data (concluded)**

Oct 1999										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
21	0100	0.75	5.1	1.30	5.6	1.41	5.3	50	1.50	10.6
	0700	0.89	5.4	1.43	5.7	1.45	5.6	52	1.49	5.3
	1300	0.81	6.0	1.31	6.3	1.34	5.9	36	1.57	5.9
	1900	0.63	6.0	1.09	6.0	1.07	6.2	70	1.31	6.7
	0100	0.54	5.9	0.99	8.9	0.97	8.9	90	1.16	6.7
22	0700	0.47	4.1	0.94	8.9	0.93	7.1	82	1.12	9.1
	1300	0.39	9.9	0.97	7.2	1.01	7.6	88	1.12	5.9
	1900	0.44	14.3	0.87	8.9	0.84	8.9	68	0.99	8.4
	0100	0.28	12.9	0.58	13.5	0.66	13.6	102	0.76	13.4
23	0700	0.42	12.9	0.65	13.5	0.69	12.0	98	0.77	12.6
	1300	0.44	12.2	0.80	12.2	0.89	12.0	94	0.97	11.8
	1900	0.50	12.2	0.71	12.2	0.72	12.0	90	1.05	12.6
	0100	0.38	12.2	0.71	11.7	0.69	10.8	104	0.78	11.2
24	0700	0.48	11.2	0.75	11.2	0.76	10.8	82	0.84	10.6
	1300	0.53	4.9	0.87	10.7	0.85	12.0	98	0.98	11.2
	1900	0.59	5.3	0.81	11.2	0.85	12.0	94	1.01	11.8
	0100	0.53	5.5	0.90	12.2	0.92	12.0	92	1.16	5.1
25	0700	0.81	5.9	1.09	5.7	1.17	13.6	98	1.38	13.4
	1300	0.57	6.3	0.99	14.3	1.10	13.6	98	1.15	13.4
	1900	0.58	12.9	1.01	12.9	1.00	13.6	78	1.15	12.6
	0100	0.36	12.2	0.77	12.2	0.81	12.0	88	0.98	11.8
26	0700	0.49	12.2	0.80	12.2	0.77	12.0	74	0.83	11.8
	1300	0.22	11.7	0.56	12.2	0.64	12.0	82	0.67	11.8
	1900	0.38	10.7	0.61	10.7	0.65	10.8	90	0.64	11.8
	0100	0.21	10.7	0.60	10.3	0.57	10.8	90	0.55	10.1
27	0700	0.30	9.9	0.56	9.5	0.54	9.8	106	0.56	10.1
	1300	0.55	4.1	0.90	10.3	0.98	4.1	6	0.56	10.1
	1900	0.70	4.6	1.09	4.5	1.21	4.8	44	0.56	10.1
	0100	0.70	5.6	1.13	5.5	1.09	5.9	52	0.56	10.1
28	0700	0.74	5.9	1.11	6.1	1.15	5.9	62	1.30	5.6
	1300	0.57	6.3	0.95	6.6	0.99	7.1	78	1.16	7.2
	1900	0.47	6.8	0.85	6.8	0.93	7.1	80	1.01	6.3
	0100	0.48	5.5	0.95	9.2	0.97	8.9	86	1.02	8.4
29	0700	0.38	7.8	0.85	8.9	0.90	8.9	82	0.98	7.7
	1300	0.41	8.9	0.78	8.6	0.81	8.9	86	0.90	8.4
	1900	0.30	8.3	0.82	8.6	0.81	8.9	88	0.90	8.4
	0100	0.38	8.9	0.72	8.6	0.73	8.2	84	0.81	8.4
30	0700	0.35	8.6	0.78	8.9	0.78	8.2	84	0.84	9.1
	1300	0.45	9.5	0.74	8.6	0.73	8.9	76	0.82	8.4
	1900	0.35	17.1	0.74	8.6	0.68	8.9	72	0.80	9.1
	0100	0.41	5.6	0.66	9.2	0.67	8.9	72	0.79	8.4
31	0700	0.40	6.0	0.72	7.2	0.77	8.9	86	0.80	9.1
	1300	0.54	6.6	0.77	9.5	0.78	8.2	110	0.79	7.2
	1900	0.36	6.1	0.71	8.9	0.75	8.9	80	0.79	9.1
	Mean	0.53	7.2	0.89	8.4	0.92	8.4	80	1.04	8.3
	Std dev	0.23	2.7	0.31	2.3	0.35	2.4	32	0.41	2.3

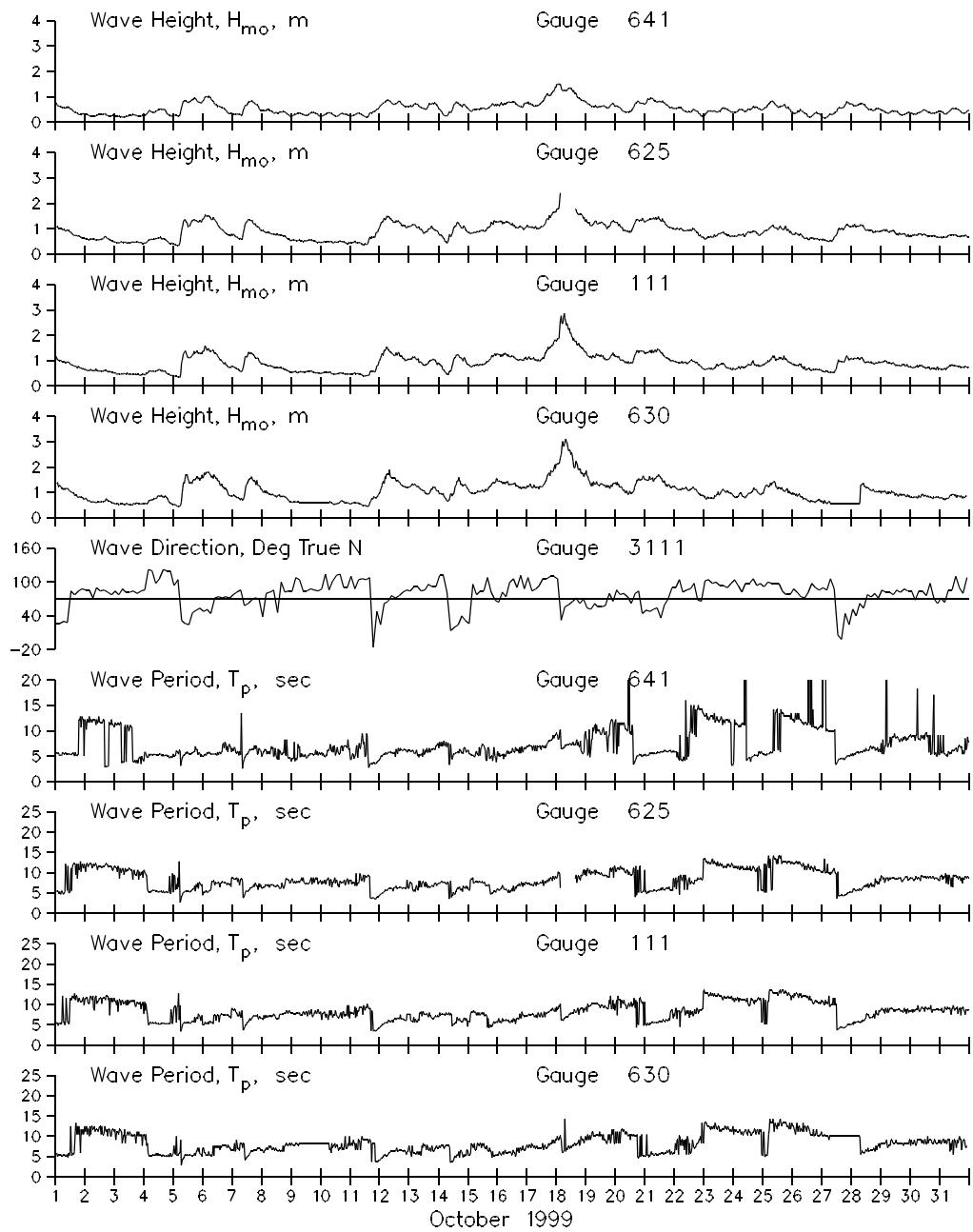


Figure 5. Wave Heights and Periods

## 4 Current Data

---

Current data (Table 5) are collected from a Sontek acoustic current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5**  
**Current Meter Data - Gauge 3539**

OCTOBER 1999																				
		Cross	Long		Cross	Long		Cross	Long											
Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir			
1	100					1300						22	100							
	700					1900							700							
	1300						12	100					1300							
	1900							700					1900							
2	100					Data							23	100						
	700					available							700							
	1300						1300						1300							
	1900							100					1900							
3	100					at a							24	100						
	700					later							700							
	1300						1300						1300							
	1900							100					1900							
4	100					date.							25	100						
	700							100					700							
	1300						1300						1300							
	1900							100					1900							
5	100						1300						26	100						
	700							100					700							
	1300						1300						1300							
	1900							100					1900							
6	100						1300						27	100						
	700							100					700							
	1300						1300						1300							
	1900							100					1900							
7	100						1300						28	100						
	700							100					700							
	1300						1300						1300							
	1900							100					1900							
8	100						1300						29	100						
	700							100					700							
	1300						1300						1300							
	1900							100					1900							
9	100						1300						30	100						
	700							100					700							
	1300						1300						1300							
	1900							100					1900							
10	100						1300						31	100						
	700							100					700							
	1300						1300						1300							
	1900							100					1900							
11	100						1300						1300							
	700							100					1900							

KEY:

+cross-shore = offshore, cm/sec  
 -cross-shore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

**Table 6**  
**Visually Observed Current Data**

Oct 1999												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	2	38	38	157	0	15	15	160	North	7	N	
2	-4	-28	28	331	-6	-19	20	323	South	10	N	
3	6	-41	41	349	1	-17	17	343	South	18	N	
4	0	-38	38	340	2	-18	19	346	South	6	S	
5	0	61	61	160	0	51	51	160	no observation			
6	0	76	76	160	-10	51	52	171	North	71	S	
7	10	68	68	151	1	25	25	157	North	14	S	
8	0	30	30	160	-4	9	10	184	North	12	N	
9	9	-17	19	7	4	-5	6	17	no observation			
10	9	-24	26	359	2	-6	7	357	South	20	N	
11	26	-14	29	42	4	-18	18	354	South	23	N	
12	-15	44	46	179	-10	38	39	174	North	22	S	
13	-23	51	56	184	3	30	31	154	South	6	N	
14	31	7	32	83	12	20	23	129	North	22	S	
15	-9	10	13	202	49	41	63	110	South	12	N	
16	no observation				46	61	76	123	North	6	S	
17	-12	20	24	191	0	30	30	160	no observation			
18	0	122	122	160	0	76	76	160	no observation			
19	0	61	61	160	9	15	18	129	North	24	S	
20	18	61	64	143	61	102	118	129	North	6	N	
21	-11	76	77	169	-9	61	62	169	North	61	S	
22	0	51	51	160	0	27	27	160	North	18	S	
23	2	14	14	151	0	-8	8	340	South	7	N	
24	0	61	61	160	37	41	55	118	North	61	S	
25	17	55	58	143	2	41	41	157	North	24	S	
26	18	-30	36	11	-10	-34	35	323	no observation			
27	14	-30	33	4	12	12	16	115	North	12	N	
28	6	61	61	154	0	61	61	160	North	45	S	
29	-1	12	12	166	12	41	42	143	North	12	S	
30	0	0	0	-3	19	19	169	South	9	N		
31	-6	-21	22	323	11	-76	77	349	South	15	N	

KEY:

+cross-shore = offshore, cm/sec  
 -cross-shore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

## 5 Visual Observations

---

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 7**  
**Visual Observations**

Oct 1999								
Day	Time	Wave Approach Angle at Pier End (degrees from True N)			Water Characteristics at Pier End			
		Primary	Secondary	Surf Zone	Width, m	Temp., C	Density g/cc	Secchi Vis., m
1	0641	50	20		115	21.5	1.0208	0.3
2	1024	65	85		46	21.8	1.0210	1.5
3	0908	80	120		74	22.1	1.0211	1.2
4	0559	90	140		62	21.9	1.0212	1.5
5	0619	0	979			22.1	1.0217	0.6
6	0624	45	0		117			0.3
7	0632	60	40		54	20.2	1.0194	0.9
8	0635	65	80		88	20.1	1.0190	1.8
9	0710	110	80		47			2.7
10	0620	80	110		64			2.1
11	1105	90	10		19	21.5	1.0213	1.8
12	0543	55	65		135			0.3
13	0701	80	60		113	20.8	1.0203	1.5
14	0621	60	0		89	20.8	1.0203	1.5
15	0613	70	60		105	20.2	1.0210	1.2
16	0630	60	75		144			
17	0628	80	70		139	20.4	1.0191	1.5
18	0700	55	10		357	20.0	1.0230	
19	0640	60	50		134	19.2	1.0175	0.3
20	0608	80	65		127	19.8	1.0188	0.6
21	0701	45	35		138	18.3	1.0220	0.3
22	0615	70	50		63	18.4	1.0185	0.6
23	0634	65	30		21	19.0	1.0202	1.5
24	1109	60	50		106	17.8	1.0202	0.9
25	0708	60	50		91	17.3	1.0205	0.6
26	0630	65	60		30	17.3	1.0206	0.9
27	0630	75	85		47	18.5	1.0216	0.9
28	0646	55	979		107	17.8	1.0218	1.2
29	0615	75	30		105	17.4	1.0216	1.8
30	0615	75	60		101	17.2	1.0206	2.4
31	0710	90			88	17.6	1.0212	

## 6 Water Levels

---

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

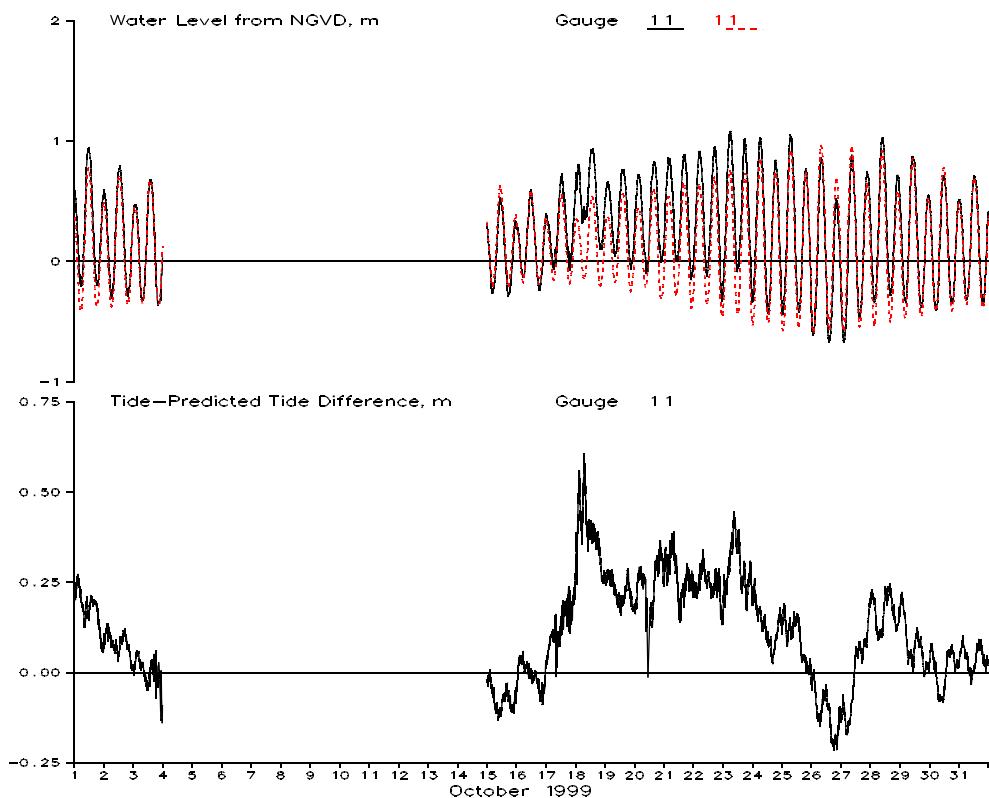


Figure 6. Water Level Variation

**Table 8**  
**Water Levels, m NGVD**

OCT 1999 Tide Levels																
Day	High			Low			Mean	Range	High			Low			Mean	Range
	Time	m	Day	Time	m	Day	m	m	Day	Time	m	Day	Time	m	m	
1	1148	0.95	1	0548	-0.21	0.37	1.16	1.16	17	0000	0.40	16	1818	-0.25	0.08	0.64
2	0018	0.60	1	1906	-0.20	0.19	0.80	0.80	17	1248	0.74	17	0618	-0.07	0.32	0.81
2	1312	0.80	2	0618	-0.31	0.26	1.11	1.11	18	0230	0.81	17	1912	-0.08	0.38	0.89
3	0142	0.48	2	1942	-0.29	0.11	0.77	0.77	18	1354	0.94	18	0536	0.32	0.62	0.62
3	1400	0.68	3	0718	-0.33	0.17	1.02	1.02	19	0206	0.67	18	2000	0.09	0.38	0.57
4	248		3	2036	No data this cycle				19	1454	0.77	19	0806	0.04	0.41	0.73
4	1506		4	842	No data this cycle				20	0324	0.72	19	2048	-0.07	0.34	0.79
5	354		4	2136	No data this cycle				20	1518		20	900	No data this cycle		
5	1606		5	942	No data this cycle				21	0336	0.87	20	2148	-0.01	0.43	0.87
6	448		5	2236	No data this cycle				21	1612	0.89	21	1048	0.00	0.42	0.90
6	1706		6	1048	No data this cycle				22	0530	0.92	21	2224	-0.16	0.39	1.08
7	536		6	2324	No data this cycle				22	1748	0.95	22	1048	-0.13	0.41	1.08
7	1754		7	1142	No data this cycle				23	0606	1.09	22	2318	-0.33	0.42	1.41
8	618		8	12	No data this cycle				23	1736	1.02	23	1124	-0.09	0.43	1.11
8	1836		8	1236	No data this cycle				24	0606	1.03	23	2354	-0.34	0.35	1.38
9	700		9	48	No data this cycle				24	1848	0.85	24	1254	-0.43	0.21	1.28
9	1912		9	1318	No data this cycle				25	0636	1.06	25	0048	-0.45	0.31	1.50
10	736		10	124	No data this cycle				25	1912	0.77	25	1330	-0.42	0.16	1.20
10	1948		10	1354	No data this cycle				26	0800	0.86	26	0130	-0.61	0.12	1.47
11	812		11	154	No data this cycle				26	2000	0.52	26	1430	-0.67	-0.08	1.20
11	2024		11	1430	No data this cycle				27	0848	0.89	27	0248	-0.68	0.10	1.56
12	848		12	224	No data this cycle				27	2124	0.75	27	1512	-0.48	0.15	1.23
12	2100		12	1506	No data this cycle				28	0936	1.03	28	0300	-0.35	0.35	1.38
13	924		13	300	No data this cycle				28	2200	0.72	28	1554	-0.28	0.22	1.00
13	2142		13	1548	No data this cycle				29	1018	0.88	29	0436	-0.35	0.27	1.23
14	1006		14	336	No data this cycle				29	2254	0.55	29	1712	-0.39	0.09	0.94
14	2218		14	1636	No data this cycle				30	1136	0.72	30	0518	-0.41	0.16	1.13
15	1042	0.53	15	0424	-0.27	0.12	0.80	0.80	31	0042	0.52	30	1818	-0.35	0.09	0.87
15	2254	0.34	15	1718	-0.29	0.04	0.63	0.63	31	1230	0.71	31	0612	-0.32	0.20	1.03
16	1136	0.60	16	0600	-0.14	0.21	0.74									

## 7 Bathymetry

---

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using a Trimble 4000 SSE GPS for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in September and the survey(s) in October on profile line 188, located 517 m south of the pier.

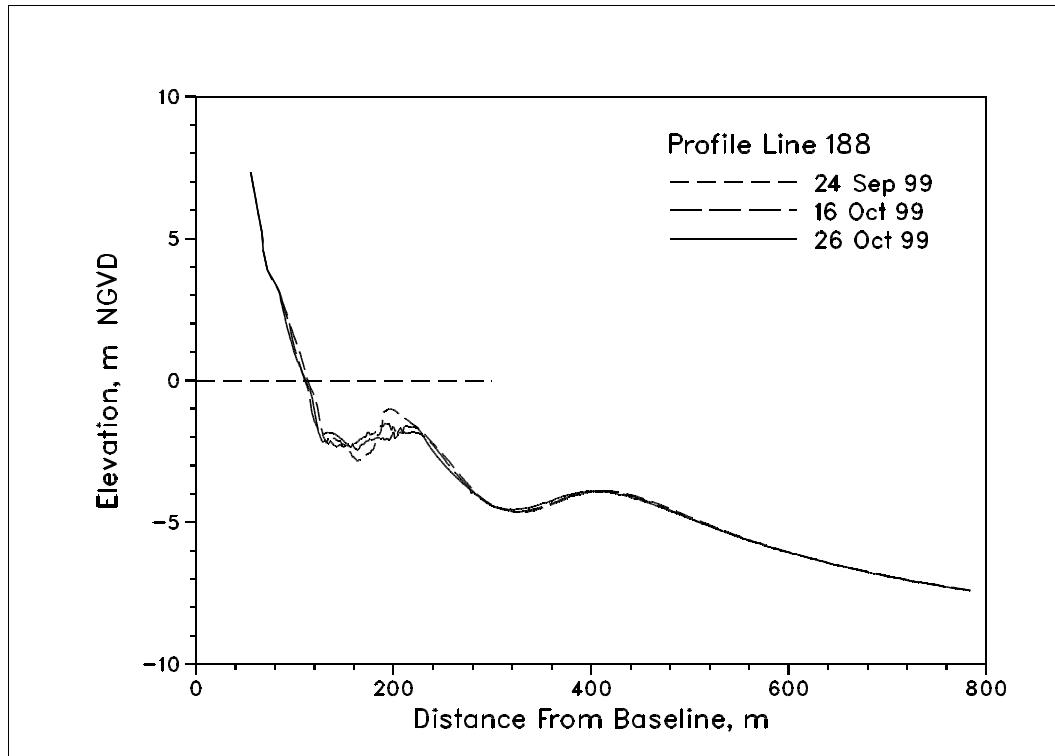


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1999. Cross-hatched areas indicate changes to the annual envelope which occurred in October.

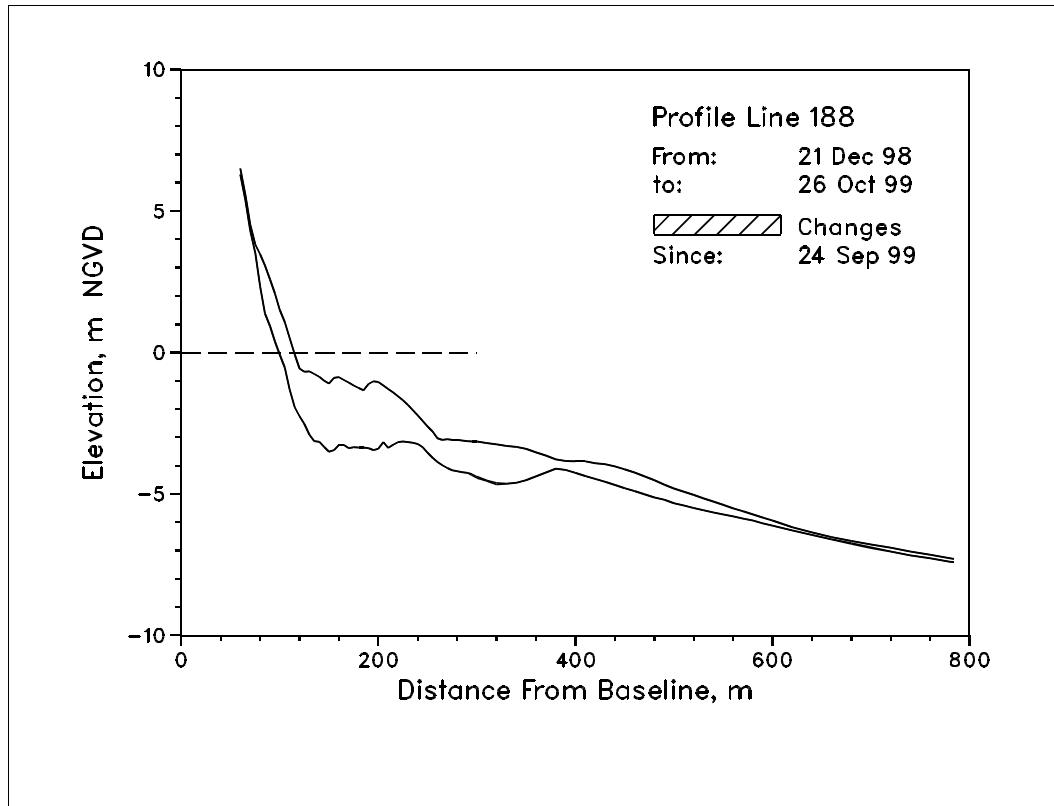


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 27 October. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

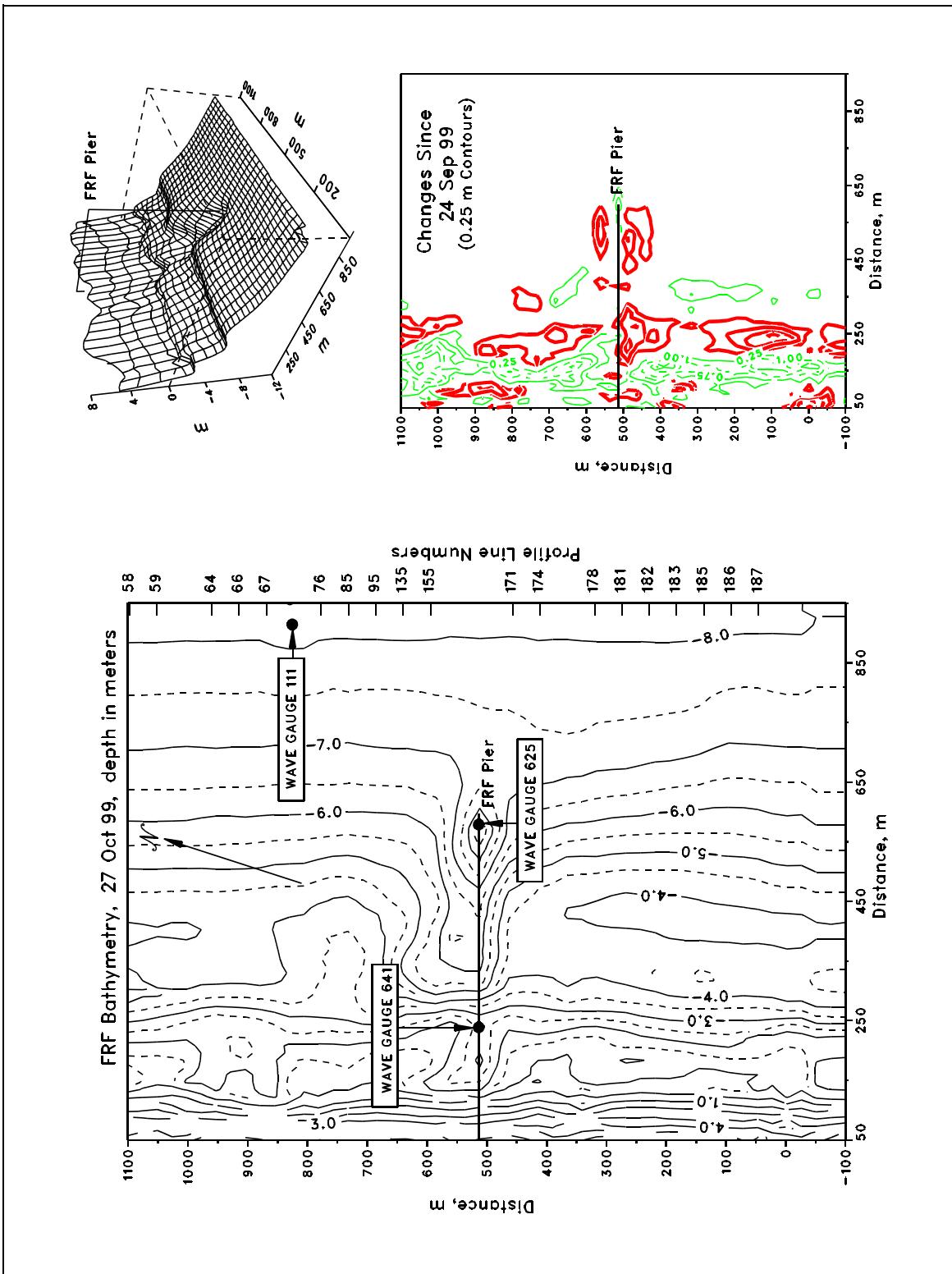


Figure 9. FRF Bathymetry, Depths Relative to NGVD